

# Strategic Energy Analysis at NREL

November 2007

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NREL/PR-670-42435

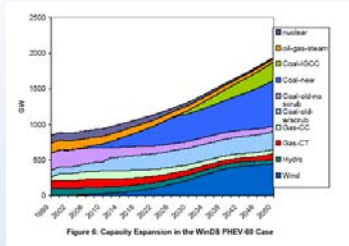
Presented at the 20<sup>th</sup> NREL Industry Growth Forum held November 6-8, 2007 in Denver, Colorado

# Strategic Energy Analysis

Integrated technical and economic analyses that advance the understanding of the value of technology in the context of dynamic global, national, and local markets, policies, energy resources and loads, and infrastructure.

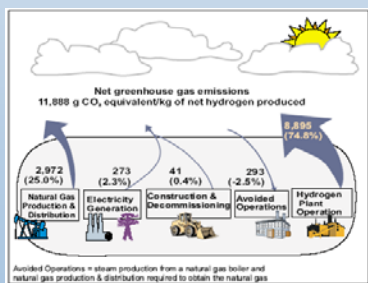
## Impact

Analyze benefits and impacts of programs, portfolios, and policy options



## System

Analyze system performance and technology interfaces in the context of the overall system



## Technology/Component

Analyze technology and component performance and cost



## Resource

Assess resource availability and characteristics

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# Some Key Themes for Analysis

## Core Areas:

Market, Technology and Policy Analysis

Energy Modeling Analysis

Renewables, Hydrogen, Alt. Fuels

Risk, Benefits, and Portfolio Analysis

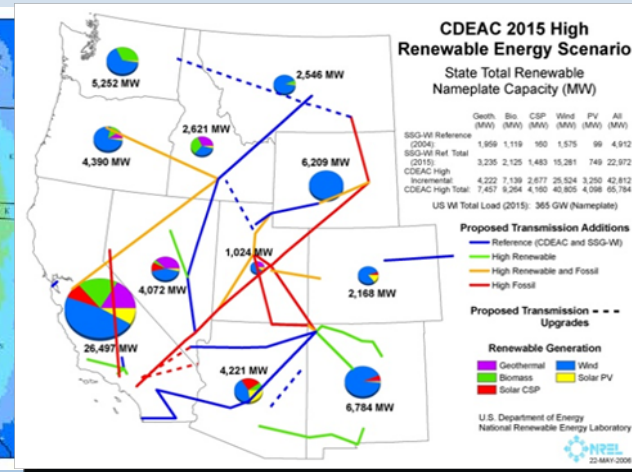
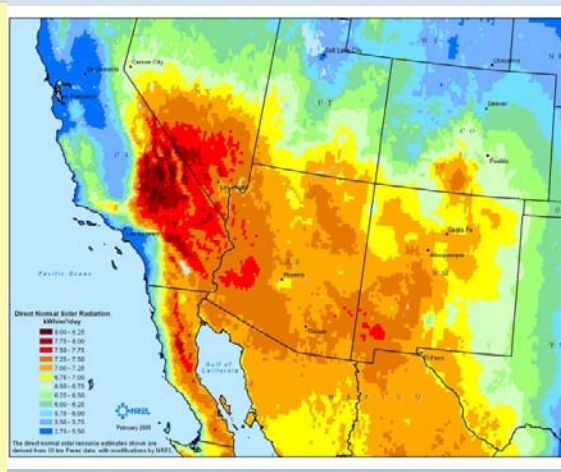
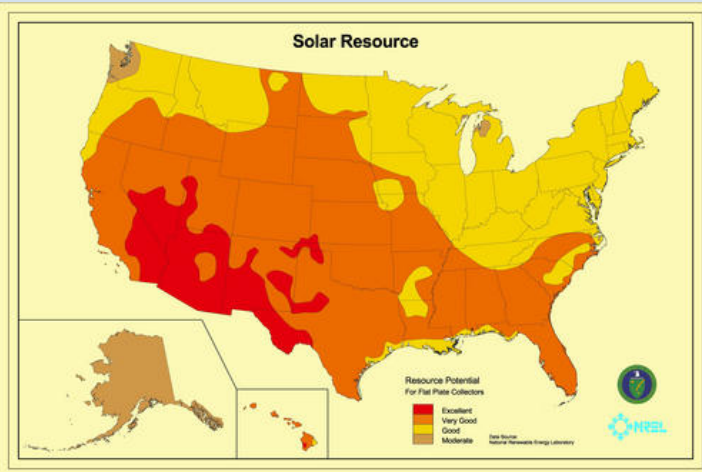


# Understanding Energy Resources and potential impact of technology advances on national goals

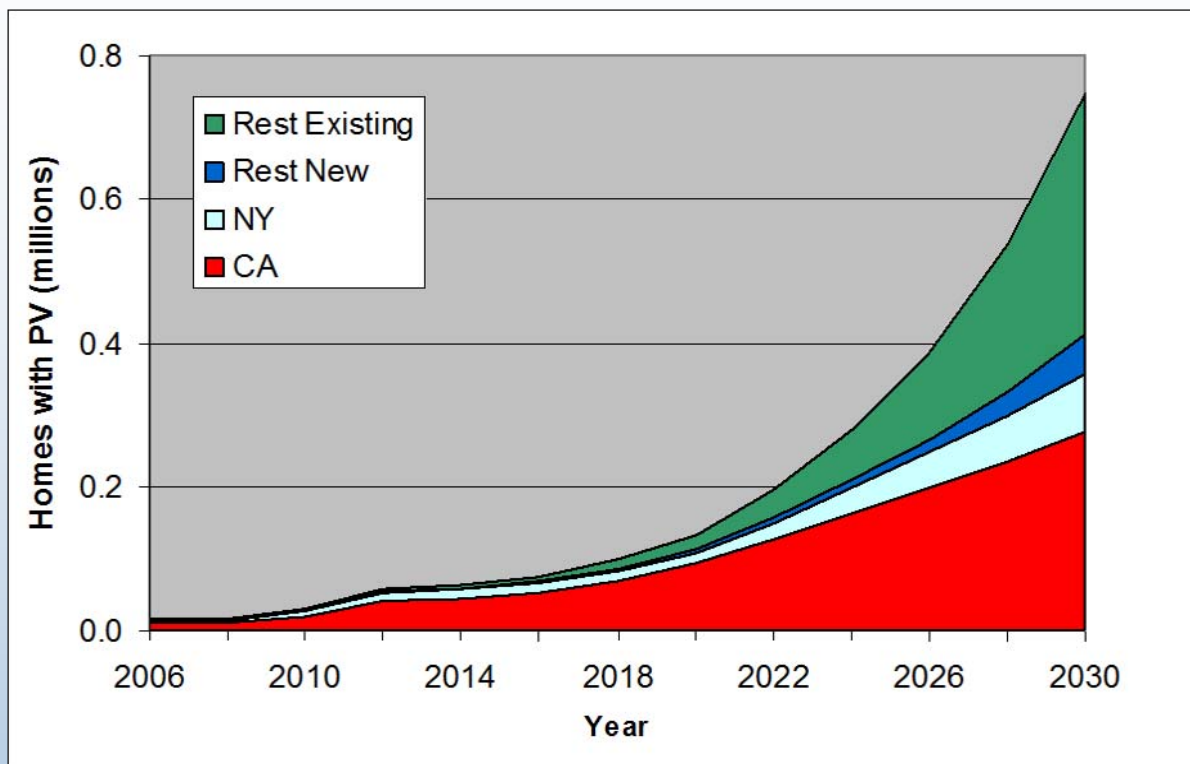
- Example: Solar resources in the Southwest. Resource (technical) potential to “economic” (e.g. commercially feasible) to “accessible” and links to transmission access, markets, pricing, technology adoption (learning) and thus technology advances....

# Solar in the SouthWest: More than just photons

- Gross irradiance is baseline: Analysis to refine to “economic potential” to accessible and linkage to technology adoption, learning and advances in technology.



# SOLARDS – PV on Buildings Market Penetration



By including rate diversity (especially tiered rates) SOLARDS captures more early adopters, especially in California. Early adoption in niche markets increases learning and penetration in other markets

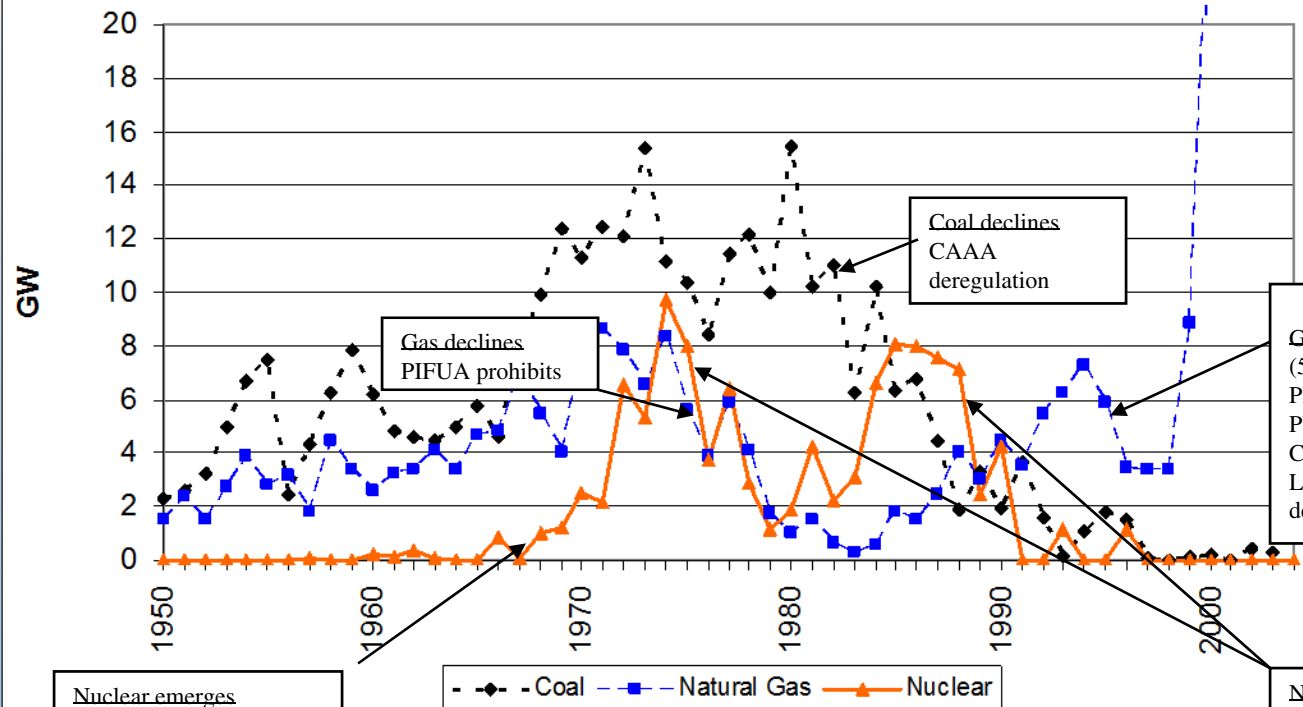
# Decisions “under uncertainty”

- Uncertainty and Translating R&D to Benefits via the applied technology pathway
  - Learning curve impacts; scale and technology advances
  - Technology adoption impacts
  - Assessing multiple pathways
  - Valuing the R&D options
    - Uncertainty, Risk, Real Options



# Many (most?) major energy market drivers are highly uncertain and outside the scope of most energy market models

**Annual Electric Generating Capacity Additions**



**Science & Technology Advances, particularly For Basis Science Are also highly uncertain**

**Gas increases**  
(50+ GW added in 2002)  
PIFUA changed  
PURPA  
CC efficiency  
Low price through deregulation

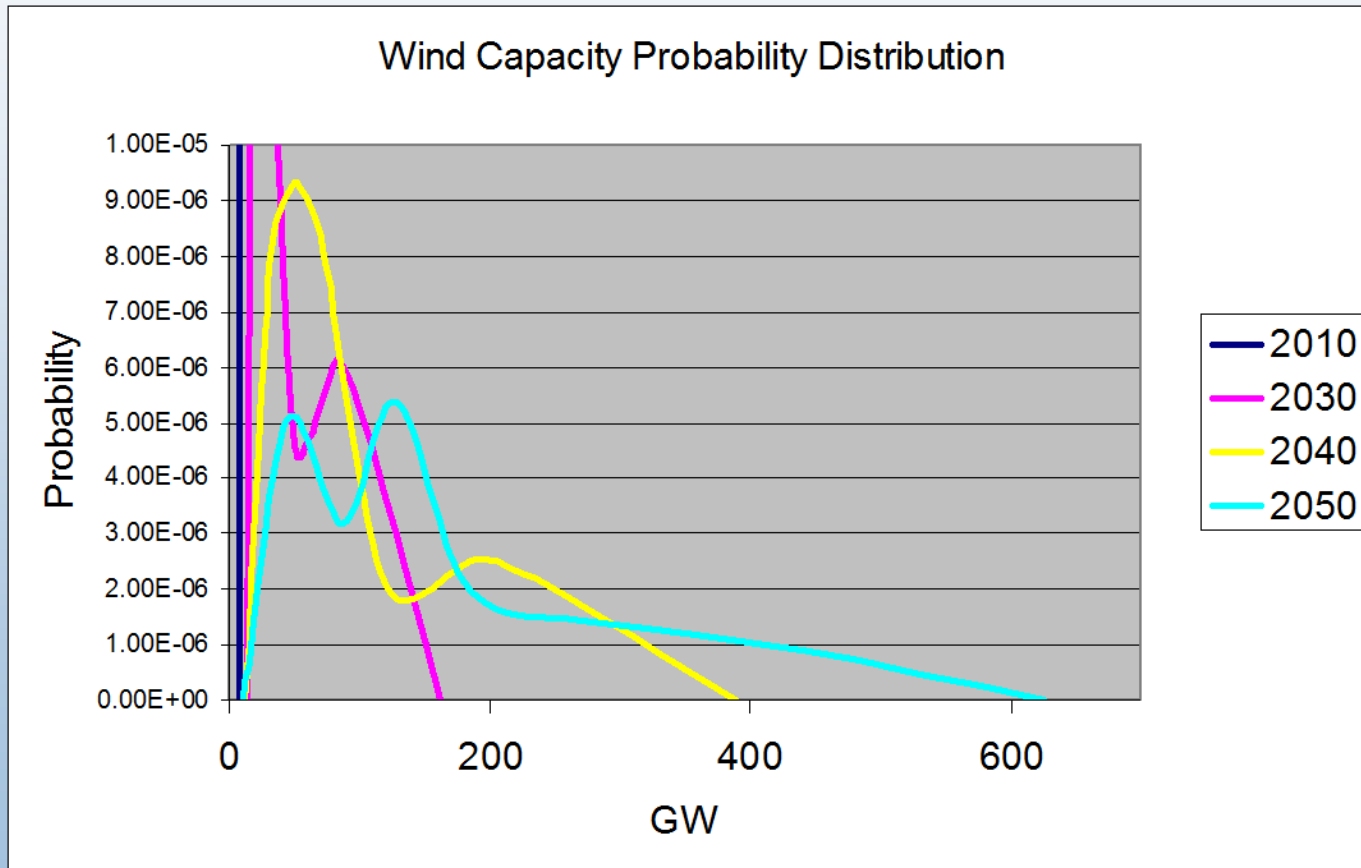
**Nuclear decline**  
Interest rates  
3-Mile Island (1979)  
Chernobyl (1986)  
Regulation

**Nuclear emerges**  
Technology Available  
Too cheap to meter

- - Coal - - Natural Gas - - Nuclear

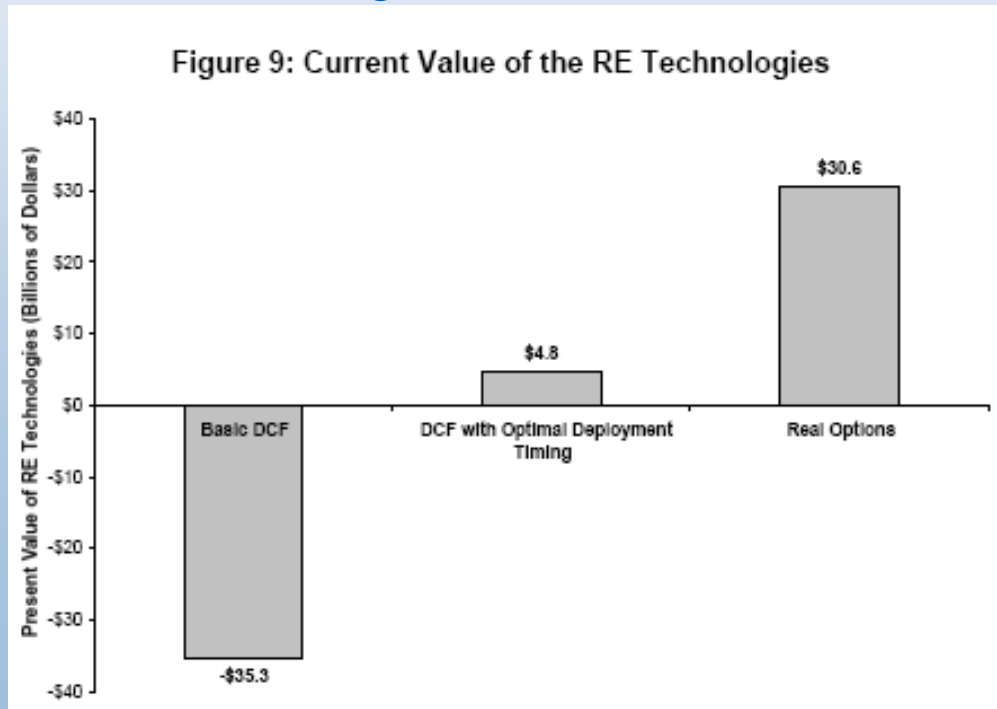
# What Might a Stochastic Model Show You?

- Incorporating uncertainty into an energy market model conveys significantly more information than a single point estimate



# “Valuation” depends on Analytic Approach

- Discounted Cash Flow (DCF) or other “linear” approaches may not be most appropriate.
- Stochastic analysis and options analysis offer alternative insights.



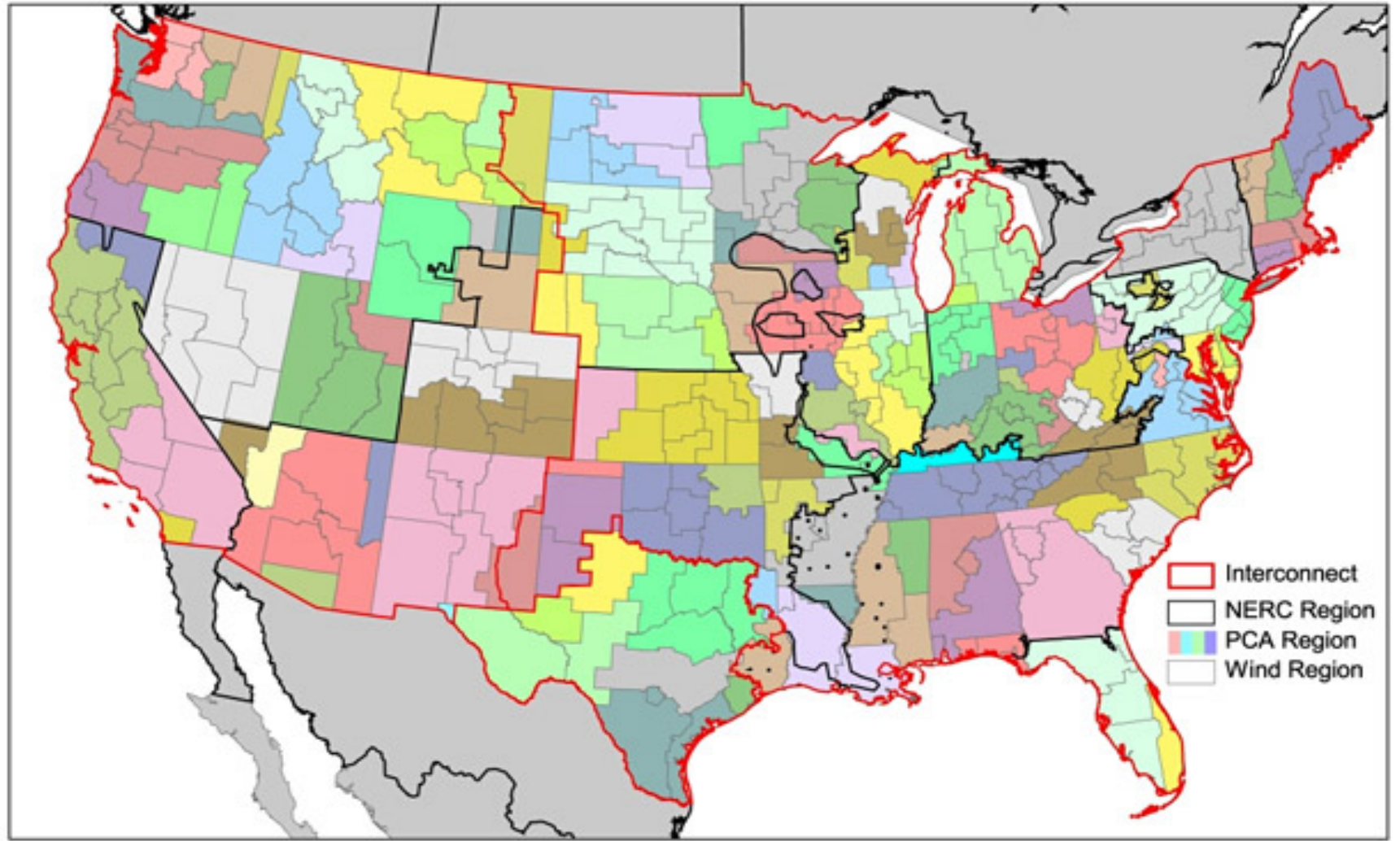
Source: **Optimizing the Level of Renewable Electric R&D Expenditures Using Real Options Analysis**, NREL/TP-620-31221, 2003

# Market Development Insights: ReEDS- Regional Energy Deployment Systems Model

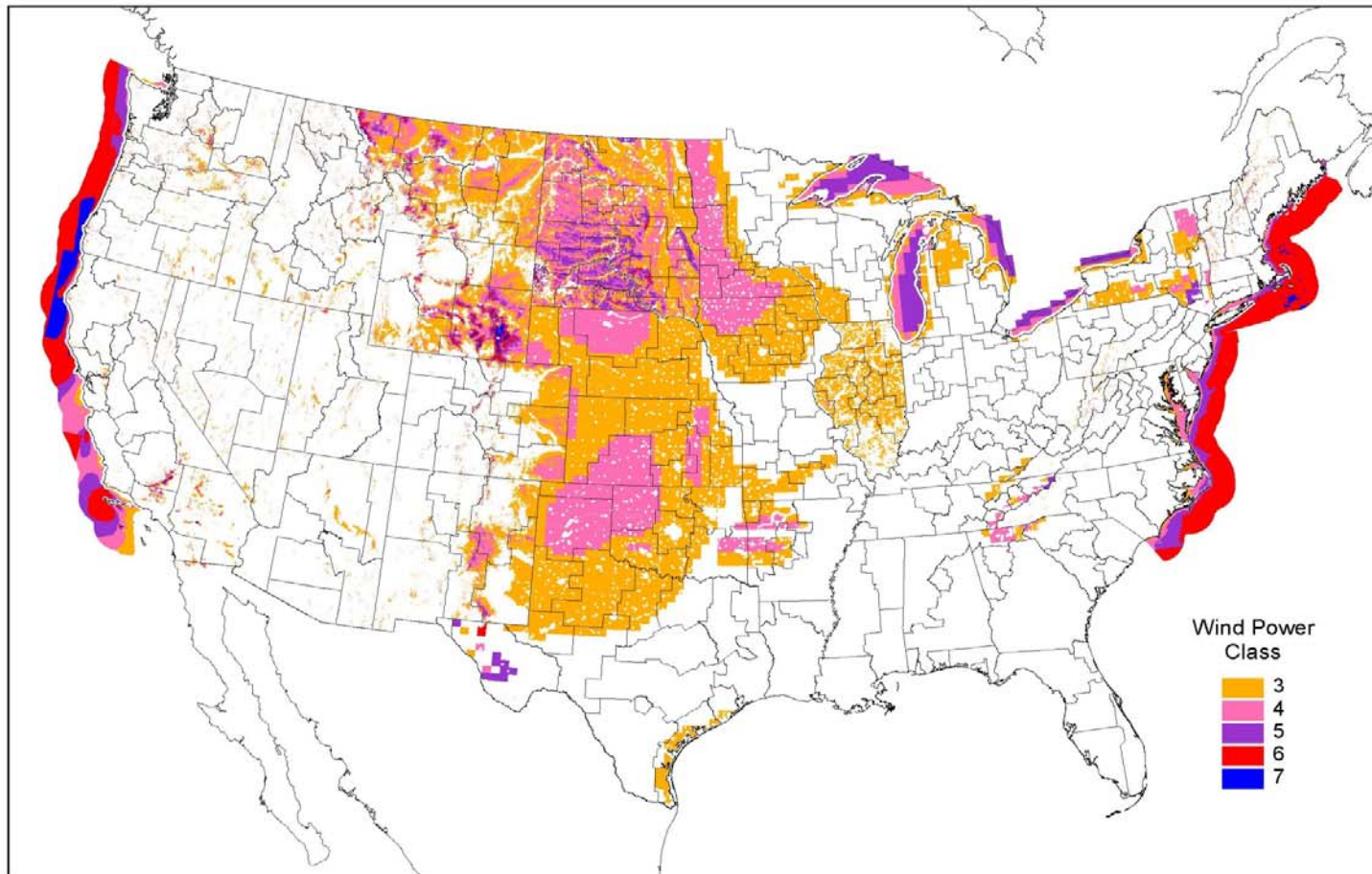
A multi-regional, multi-time-period model of capacity expansion in the electric sector of the U.S.

Designed to estimate market potential of energy technologies in the U.S. for the next 20 – 50 years under different technology development and policy scenarios

# ReEDS Model: Detailed Treatment of Wind Grid Integration Issues

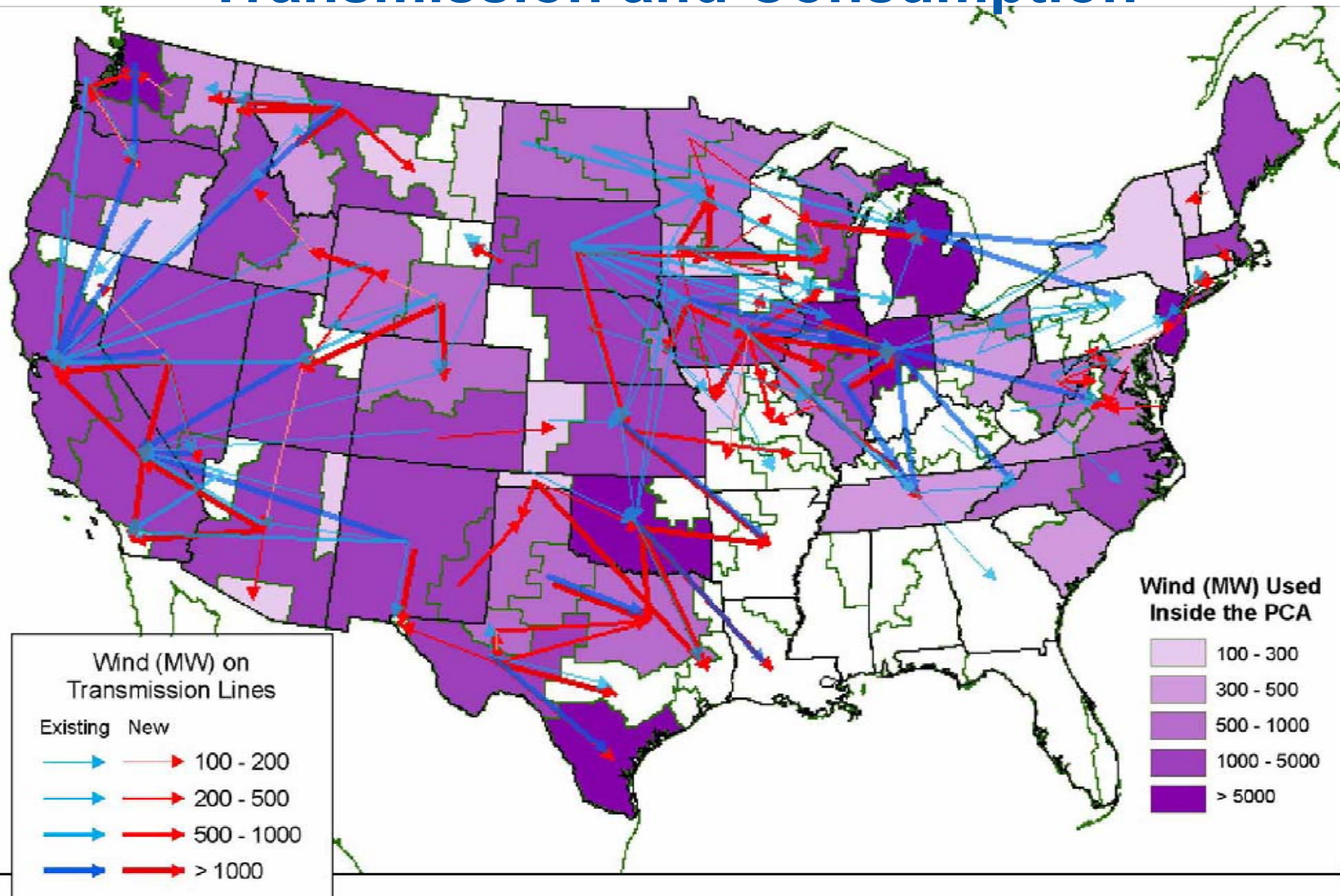


# Wind Resources in WinDS

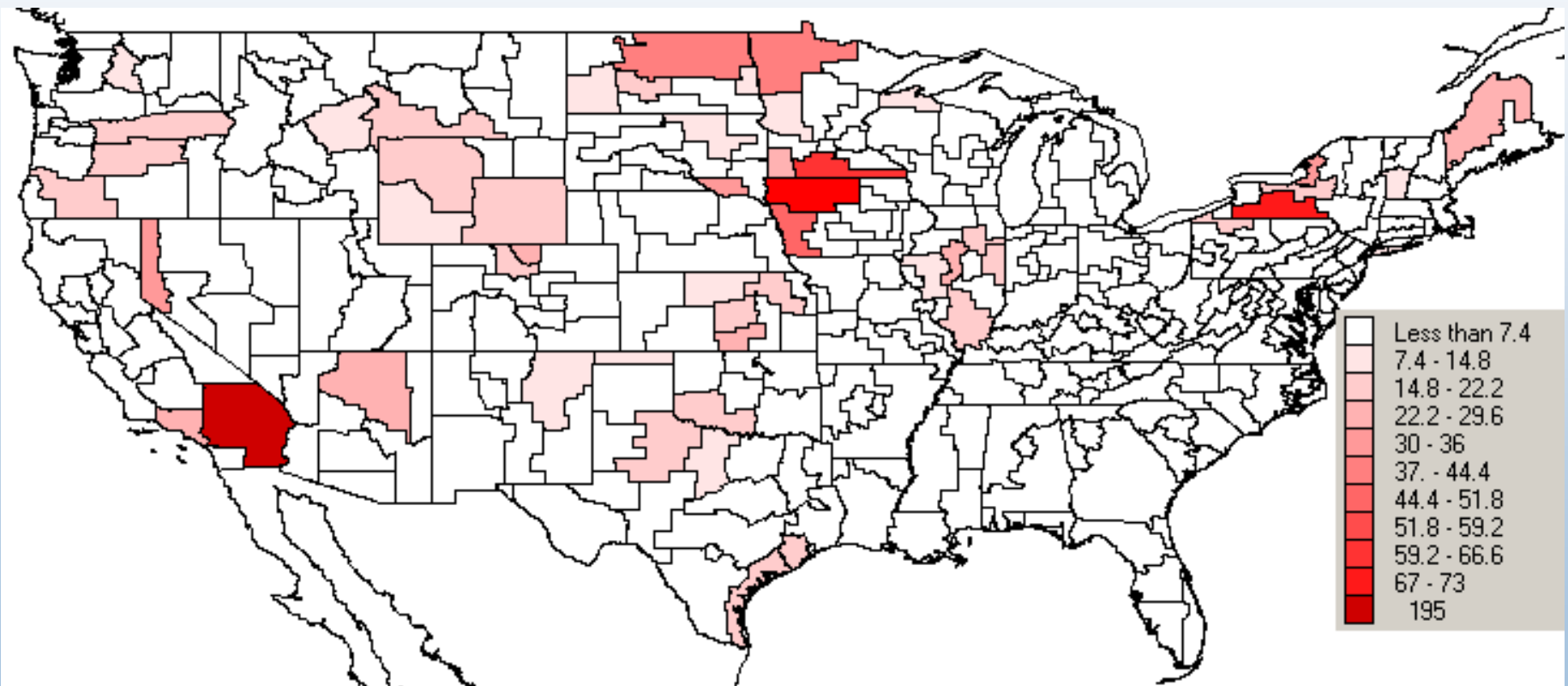




# WinDS 2030 RPS: Transmission and Consumption



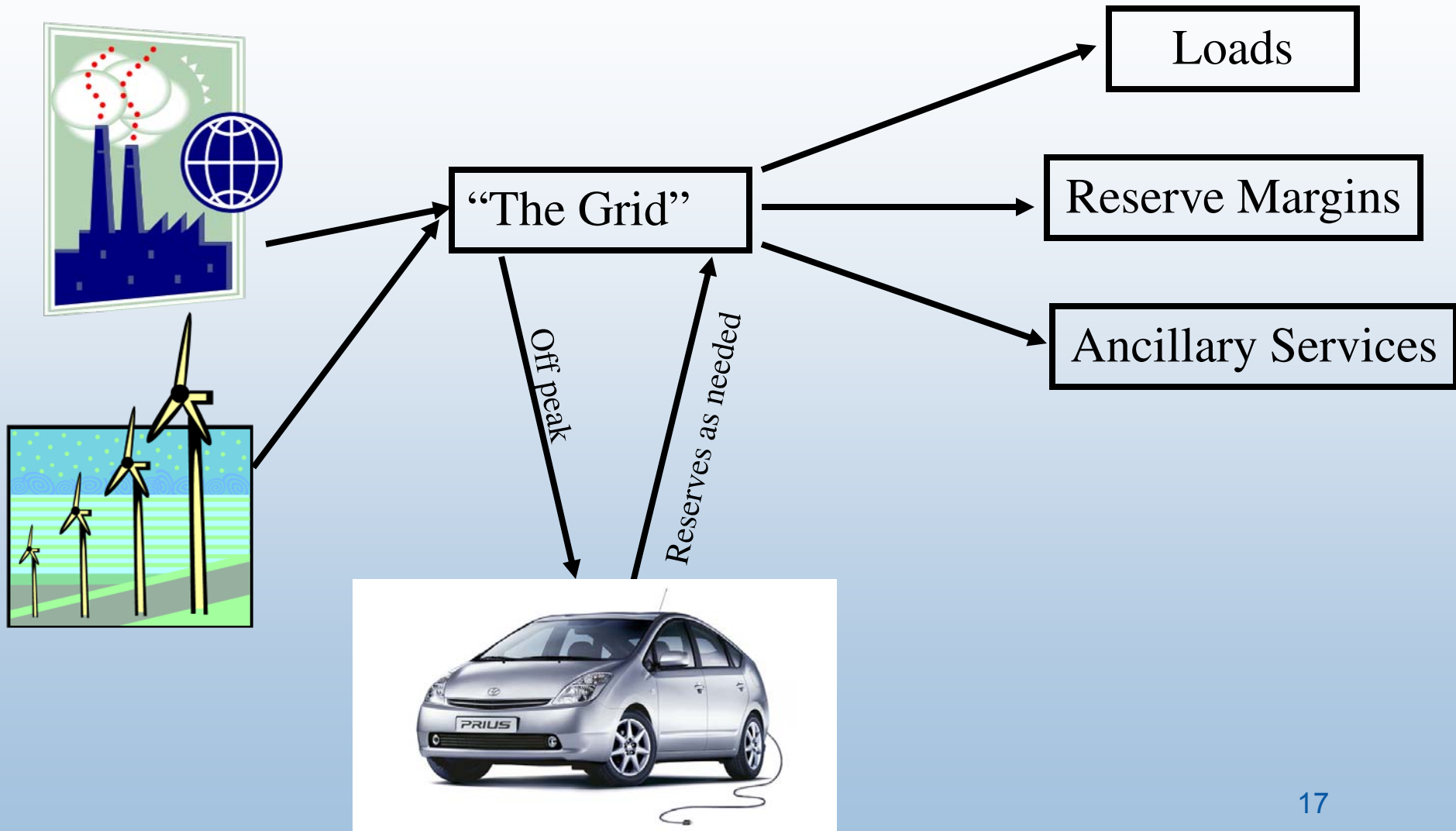
# Base Case H<sub>2</sub> Production\* from Wind



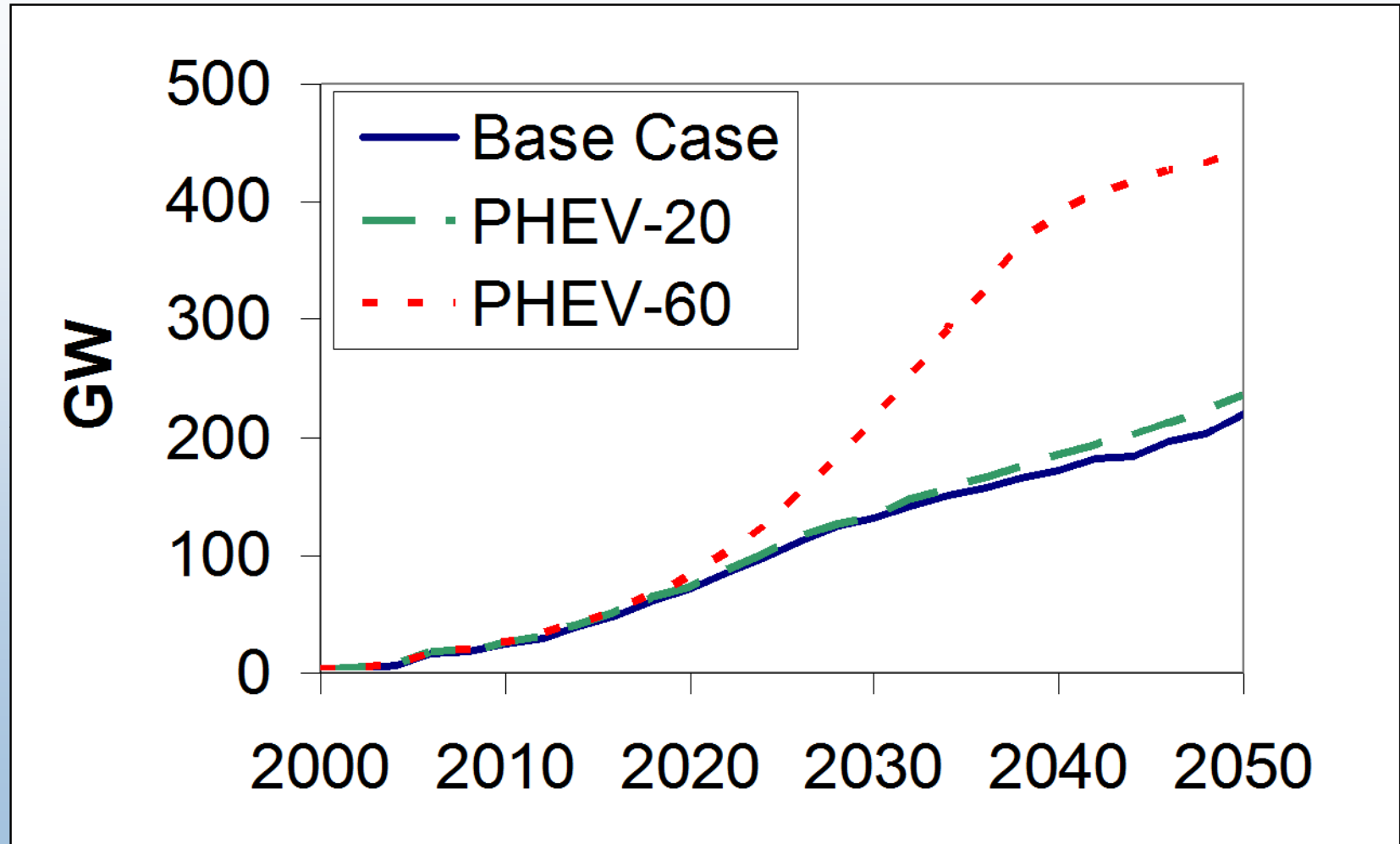
\* Kilotons/yr



# Plug-in Hybrid Electric Vehicle Modeling

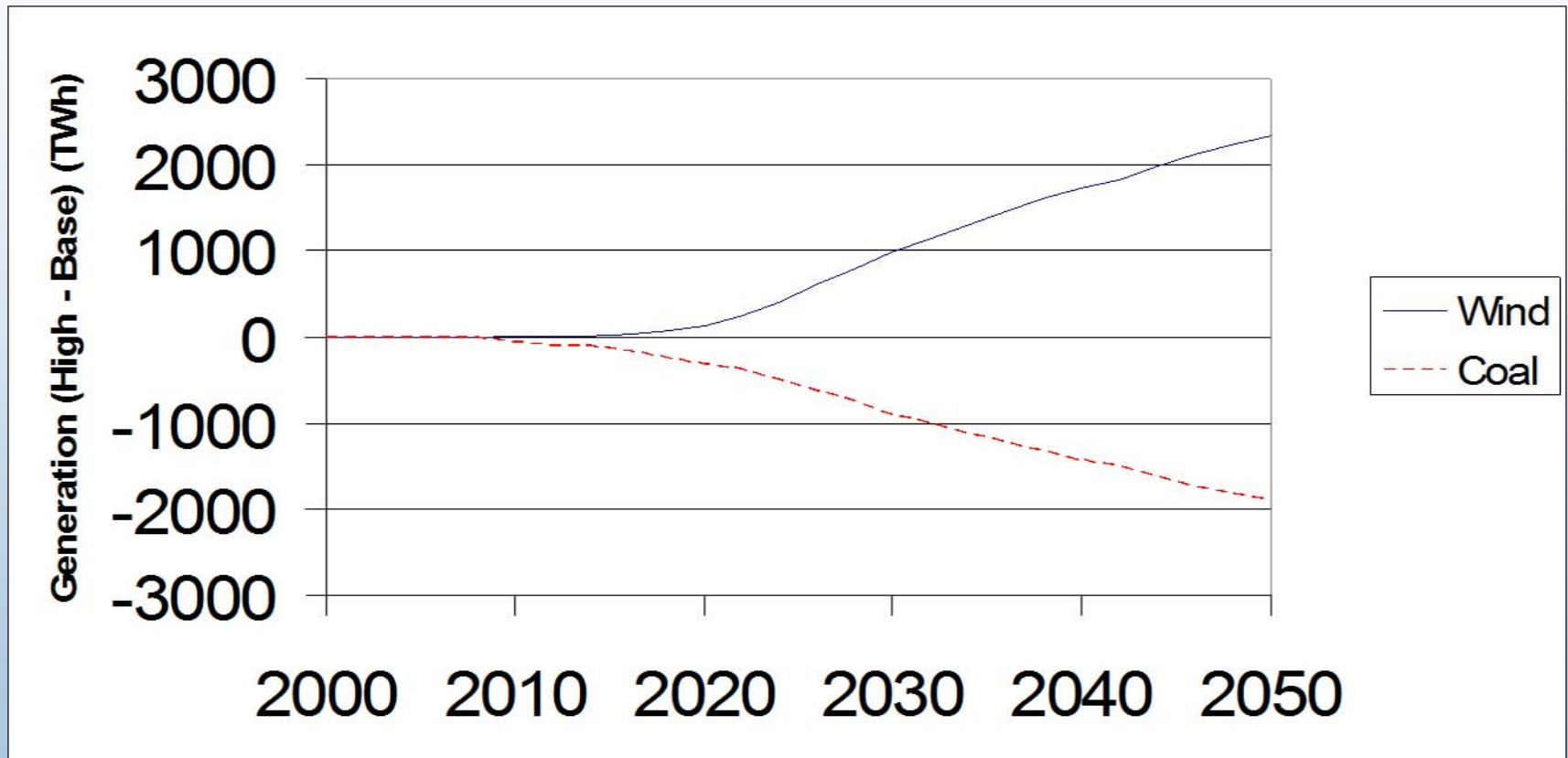


# PHEVs\* Can Increase Wind Penetration



\* Assumes 50% PHEV-V2G penetration by 2050

# Coal Generation: PHEV60 – Base Case



# Industry Partnerships

- Who:
  - Utilities
  - Corporations
  - Developers
  - Investors
- What:
  - Strategic Planning
  - Market Insights
  - Scenario Modeling & Impacts
  - Expert Review
  - Transformational Applications

# PHEVs: What are the Impacts to Xcel Energy\*?

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- Infrastructure Utilization
- Additional Load
- Production Costs
- Capacity Impacts
- Emissions

**UNKNOWN**

Can Xcel Energy mitigate adverse impacts with controls or incentives?

## ***Sneak Preview***

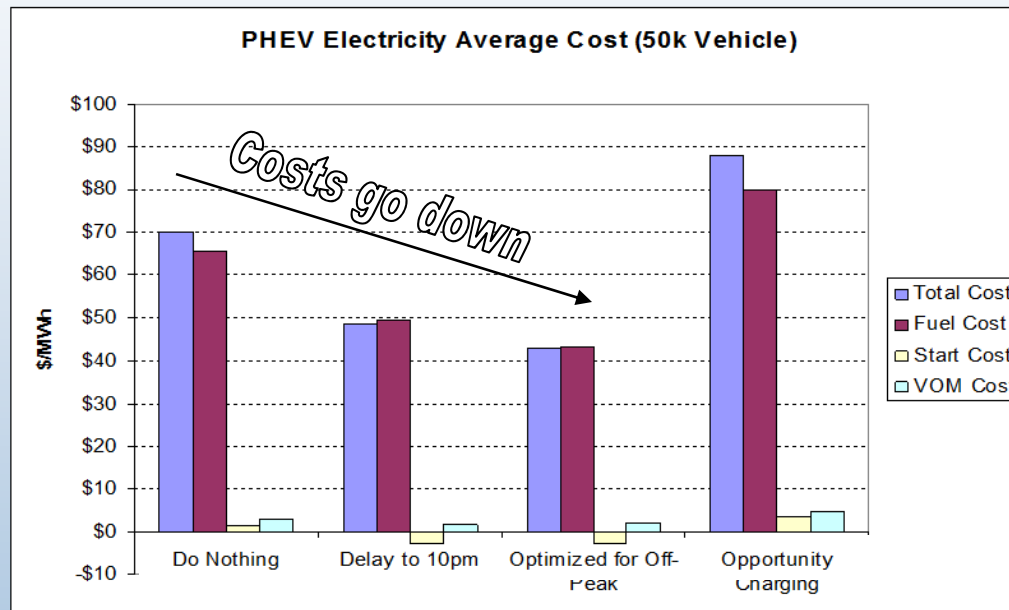
Time of charging matters...

Coincident peak loading matters...

Tailpipe versus upstream emissions matters...

# Incremental Cost (Generation Capacity)

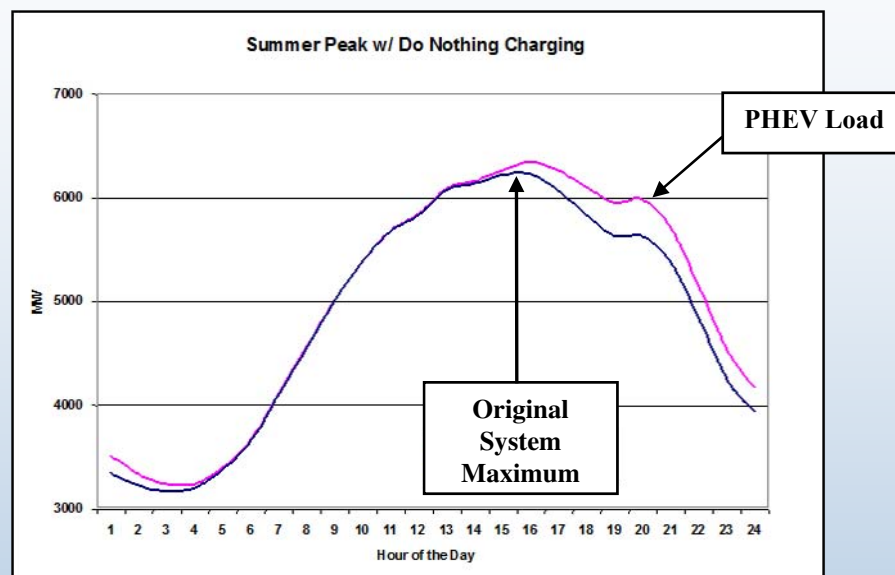
- Costs are dominated by fuel cost
- As power is moved to the off-peak period...



- Opportunity charging is the most costly charging strategy, but utilizes 75% more energy

# Incremental Cost (Generation Capacity)

- Coincident peak loading necessitates additional generation capacity
- *Delay to 10pm and Optimize to Off-Peak* scenarios avoid capacity expansion costs

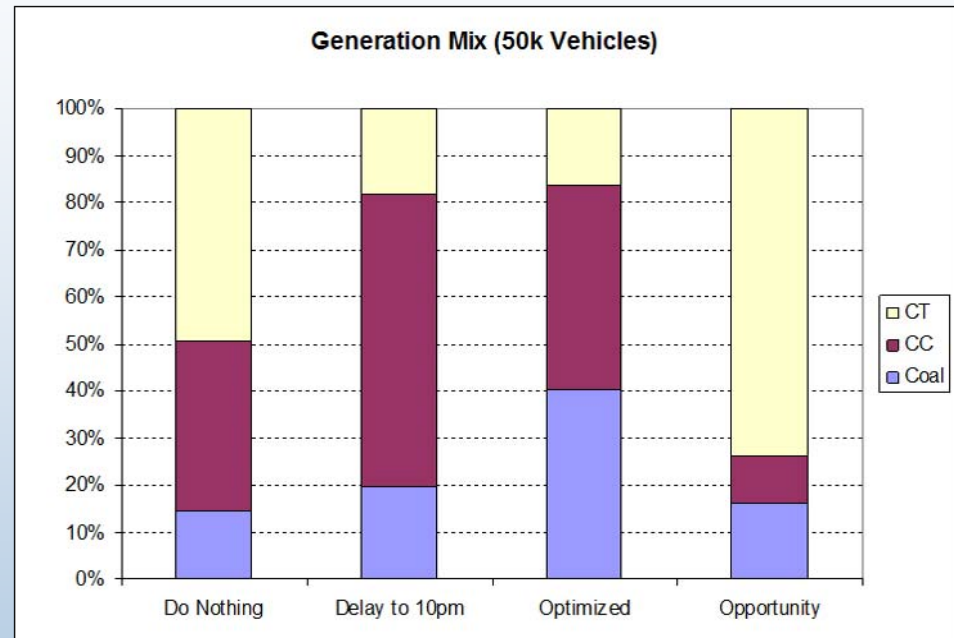


Charging Scenario	Annual Capacity Costs
Do Nothing	\$126/kW* @ .238 kW/car = \$30/car
Opportunity Charging	\$126/kW* @ .548 kW/car = \$69/car

\*Assumptions: 15% IRR; 20% Capacity Margin; \$700/kW overnight cost (combustion turbine)

# Incremental Cost (Generation)

- Two significant changes when shifting PHEV load to the off-peak
  - *Delay to 10pm* shifts generation from CT to CC
  - *Optimized to Off-Peak* then shifts generation from CC to coal steam.
- Opportunity charging largely served by CT



\*Other generation such as hydro, diesel, and wind are small contributors to incremental generation and are excluded from this graph



# Synopsis

- Core Strengths:
  - Technoeconomic Systems Analysis
  - Geospatial Energy Economics
  - US Markets for RE/EE Technology
  - Policy and Technology Options Analysis
  - Uncertainty, Risk, and R&D Portfolio expertise